

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
15 January 2004 (15.01.2004)

PCT

(10) International Publication Number  
**WO 2004/005039 A1**

(51) International Patent Classification<sup>7</sup>: **B41M 5/00**

(21) International Application Number:  
PCT/US2003/020420

(22) International Filing Date: 30 June 2003 (30.06.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
10/189,160 3 July 2002 (03.07.2002) US

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: **INK-JET RECORDING MEDIUM, METHOD FOR RECORDING A WATER-RESISTANT IMAGE ON THE MEDIUM AND THE RECORDED MEDIUM**

(57) Abstract: Inkjet recording medium suitable for recording images with dye and pigmented inks, comprising a substrate coated with a first ink-receptive layer of a polymeric binder and a cross-linker and a second layer of 45-98% of polymeric binders where at least one binder is a copolymer of hydroxyethylmethacrylate, a polymer and copolymer of vinylpyrrolidone, a fully or partially hydrolyzed polyvinyl alcohol and its derivatives, or combination thereof. The second layer optionally further contains at least one nitroeneous polymer or non-polymeric nitroeneous compound, or a mixture thereof, having a pKa of at least 8 and preferably greater than 9. The substrate provides high quality printed images when printed with an ink containing a reactive dye having ionizable and/or nucleophilic groups capable of reacting with the coating agent in one or more of the two layers. Printed images are bleed-resistant, water-resistant, and/or are characterized by an enhanced chroma and hue.

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# INK-JET RECORDING MEDIUM, METHOD FOR RECORDING A WATER-RESISTANT IMAGE ON THE MEDIUM AND THE RECORDED MEDIUM

## TECHNICAL FIELD

The present invention relates generally to an ink-jet recording medium having at least two layers coated upon a substrate such as paper, and more particularly relates to a novel ink-jet recording medium, method for recording a water-resistant image on the medium using an ink-jet printer and the resulting recorded medium, thereof.

## BACKGROUND

As printing technology advances, paper manufacturers are faced with the increasingly rigorous demands of their customers for high quality paper that is economically attractive. For example, there is a great demand for paper of high enough quality to be suitable for printing of a digital image with an ink-jet printer where the look and feel of the product approaches that of a photograph. Thus, there is a keen demand for papers that meet high quality standards with respect to brightness, opacity, and dry and/or wet strength, and that, upon printing with any of a wide range of colorants, provide a water-resistant printed image. Customers further demand that such papers be amenable to use with a variety of printing techniques, including not only conventional printing techniques, but also "impact free" printing techniques such as inkjet printing (particularly colored inkjet printing), laser printing, photocopying, and the like.

In response, paper manufacturers have attempted to meet their customers' demands for such high quality paper through a process termed "sizing." "Sizing," which encompasses both "internal sizing" and "external sizing," affects the manner in which colorants and particularly ink interact with the fibers of the paper. "Internal sizing" involves introduction of sizing compositions within the entire fibrous mass at the pulp stage of paper manufacturing (i.e., to the wet pulp, or more specifically, to the prepared papermaking furnish) before the stock is formed into a sheet, resulting in the distribution of the sizing composition within the entire fibrous mass that is subsequently used to produce the fibrous paper sheet. "External sizing" (also referred to as surface application, pasting, saturating or coating) involves application of a sizing composition to at least one surface of a fibrous paper sheet, so that the composition is present on or in at least one of the two faces of the fibrous sheet. Paper and paper-based products are internally and/or externally sized to increase the resulting paper's strength, resistance to picking and scuffing, and resistance to undue penetration of water, organic solvents, oils, inks, and

various types of aqueous solutions. Sizing is also used to improve the paper's smoothness and optical characteristics. In general, sizing is recognized to confer a number of advantages, including but not limited to the foregoing, with perhaps resistance to penetration of water and aqueous inks (e.g., bleed resistance) of utmost importance.

5           Various materials have been used as external and/or internal sizing agents, such as conventional and modified starches, polyvinyl alcohol, cellulosic derivatives, gelatin, rosin, proteins such as casein, natural gums and synthetic polymers. Internal sizing agents are generally referred to as acid, neutral, or alkaline internal sizes. Acid sizes are typically rosin based and precipitated by alum. Neutral sizes may also be rosin-based, and are used  
10          at near-neutral pH, while alkaline sizes are synthetic materials such as alkenyl succinic anhydride (ASA) and alkyl ketene dimer (AKD).

          Although these materials are effective to various degrees under certain conditions, use of each is associated with certain limitations. For example, it is often necessary to use large amounts of these conventional sizing agents in order to provide paper having the  
15          desired properties. However, the opacity and brightness of the paper substrate decrease in direct proportion to the amount of sizing agent applied to the paper. Moreover, as the amount of sizing agent and/or the cost of the sizing agent increases, the cost of producing the paper increases, making high quality papers prohibitively expensive. Certain sizing agents impart relatively poor bleed resistance and water resistance of imprinted inks, and  
20          thus must be used with insolubilizing agents to ensure production of a printed paper having satisfactory water resistance.

          In addition, sizing agents usually require multiple application layers, which is time consuming and expensive. Also, beading of water from ink-jet inks can cause a specked or grainy image on the paper when the digital image sent to the printer was much clearer.

25          Conventional and modified starches are the most common sizing agents in use in the industry. Exemplary starch-based sizing agents include hydrophobic starches (see, e.g., U.S. Pat. No. 2,661,349), blends of hydrophobic and non-hydrophobic starches (see, e.g., U.S. Pat. No. 4,239,592; EP 350,668), and blends of treated starches and/or cationic starches (see, e.g., U.S. Pat. No. 4,872,951; EP 620,315; U.S. Pat. No. 5,647,898).  
30          However, while starches may provide improved porosity, these compounds generally do not provide for improved bleed resistance or water resistance of inks printed on the treated paper substrates.

Several synthetic sizing agents are presently available, and may be used in internal sizing and/or external sizing processes. Exemplary synthetic sizing agents include hydrophobic cellulose reactive sizing agents (see, e.g., U.S. Pat. Nos. 4,478,682; 3,840,486), cationic polymers (see, e.g., U.S. Pat. No. 3,006,806), and water-soluble, poly(aminoamide) resins (see, e.g., U.S. Pat. No. 4,478,682). Synthetic compounds have also been used to enhance the dry and/or wet strength of paper (see, e.g., U.S. Pat. Nos. 5,138,669; 3,058,873; 5,510,004; 5,659,011), either at the internal sizing or external sizing steps. However, synthetic sizing agents tend to be expensive, due to both the cost of the starting material and the amount that is required to provide a paper substrate having the desired characteristics.

Use of conventional sizing agents normally results in a decrease in the porosity of the final paper substrate; thus, while the sized paper substrate may have the desired brightness and opacity, it may not provide for a printed image having a suitable optical density or color intensity. In addition, as the porosity of the paper increases, the paper becomes less amenable to various handling processes during manufacturing. For example, envelope manufacturers demand that the paper available to them have a relatively low porosity. If the porosity of the paper is too high, the paper is too stiff for handling by automated industrial devices for folding and sorting (e.g., devices of the "suction extractor" type) during envelope production. In contrast to lower porosity papers, high porosity papers also require slower machine speeds, and further require refining and draining operations that have relatively high energy costs. Both of these requirements result in decreases in plant productivity, efficiency, and cost effectiveness.

Paper manufacturers have also attempted to improve the water resistance of printed images on paper using various coating methods and compositions. For example, U.S. Pat. No. 5,709,976 describes coated paper having a hydrophobic barrier layer, which is composed of a water insoluble component and a water soluble or alcohol soluble anticurl agent, and an image receiving coating on the hydrophobic barrier layer, where the image receiving coating is composed of a polymeric binder, a dye fixative, a lightfastness inducing agent, a filler, and a biocide. While the coated paper provides for printed images having improved water resistance, the preparation of the coated paper requires multiple steps, e.g., a first step to coat the paper with a hydrophobic barrier layer, and then a second step to coat the paper with an image-receiving coating. These additional steps translate to additional manufacturing costs. Moreover, the components of such conventional coating compositions are often quite expensive, further adding to production costs.

There is a need in the field for coating agents and methods that provide an effective, cost efficient means for producing paper that yields a high quality, water-resistant printed image, that are amenable for use with a wide variety of paper substrates, and that are compatible with conventional manufacturing and post-manufacture handling processes. There is a need for agents that lend themselves to even a single coating layer, although multiple layers may be used. There is a particular need for coating agents and their coated substrate where an image printed using an ink-jet mechanism has the look and feel of a photograph produced by conventional photographic printing techniques.

#### SUMMARY OF THE INVENTION

The present invention provides an inkjet recording medium suitable for recording images with dye and pigmented inks, comprising a substrate coated with at least two layers comprising:

- (a) a first ink-receptive layer comprising a polymeric binder, a cross-linker and optionally having a plasticizer coated over the substrate; and
  - (b) a second layer comprising of 45 to 98% of polymeric binders where at least one binder is selected from the group consisting of:
    - (i) copolymers of hydroxyethylmethacrylate, a polymer and copolymer of vinylpyrrolidone, and
    - (ii) a fully or partially hydrolyzed polyvinyl alcohol and its derivatives, and combination thereof,wherein the second layer further contains at least one nitrogenous polymer, at least one non-polymeric nitrogenous compound, or a mixture thereof, wherein the nitrogenous polymer or nitrogenous compound has a pKa higher than 8,
- wherein said first layer is located between said second layer and the substrate in said recording medium. The paper substrate provides high quality printed images when printed with an ink containing a reactive dye having ionizable and/or nucleophilic groups capable of reacting with the coating agent in one or more of the two layers. Images printed on this paper substrate are bleed-resistant, water-resistant (e.g., water-fast), and/or are characterized by an enhanced chroma and hue. Such images sometimes take on the look and feel of a photograph that is produced by conventional photographic processes.

It is a primary object of the invention to address the above-mentioned need in the art by providing a ink-jet recording medium that efficiently binds colorant upon printing,



and thus provides an economical, efficient means for processing of paper to provide a high quality printed image thereon.

Another object of the invention is to provide a printed, ink-jet recording medium on which the printed image is high quality (particularly with respect to optical density and  
5 brightness), bleed-resistant and water-resistant.

Still another object of the invention is to provide a method for recording an image or the ink-jet recording medium according to the present invention to provide water-resistant (e.g., water-fast) images thereon. Additional objects, advantages and novel  
10 features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned by practice of the invention.

## DETAILED DESCRIPTION OF THE INVENTION

### Definitions and Nomenclature

It must be noted that, as used in the specification and the appended claims, the  
15 singular forms "a," "an" and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a monomeric guanidine compound, a biguanidine compound or a guanidine oligomer" in a composition means that more than one guanidine compound or oligomer or more than one biguanidine compound, or a mixture thereof, can be present in the composition, reference to "a film-forming binder" in  
20 a composition means that more than one film-forming binder can be present in the composition, reference to "a guanidine oligomer or biguanidine compound" includes combinations of different guanidine oligomers as well as mixtures of biguanidine compounds or guanidine or a combination thereof, reference to "a coating agent" includes mixtures of different coating agents, and the like.

25 The term "paper" or "paper substrate" with reference to the ink-jet recording medium is meant to encompass any substrate based on cellulosic fibers; synthetic polymer films and fibers such as polyamides, polyesters, polyethylene, and polyacrylic; inorganic fibers such as asbestos, ceramic, and glass fibers; and any combination of cellulosic, synthetic, and inorganic fibers or a combination of cellulosic fiber and synthetic polymer  
30 films produced by extrusion or coating the cellulosic fiber substrate. The paper or paper substrate can be composed of compressed natural or synthetic fibers, of compressed natural or synthetic solids, or of a woven appearance such as a textile or canvas. The paper or paper substrate may be an opaque or a see-through substrate such as used with an

overhead projector, and the substrate may be of any dimension (e.g., size or thickness) or form (e.g., pulp, wet paper, dry paper, etc.). Also, the paper or paper substrate can have a smooth or textured appearance, e.g., a canvas-look texture. In most instances, the "paper" or "paper substrate" has been subjected to an external sizing process prior to treatment  
5 according to the methods of the invention, however sizing is not required. The paper substrate is preferably in the form of a flat or sheet structure, which structure may be of variable dimensions (e.g., size and thickness). "Paper" is meant to encompass printing paper (e.g., inkjet printing paper, etc.), writing paper, drawing paper, and the like, as well as board materials such as cardboard, poster board, Bristol board, and the like.

10 The term "sheet" or "flat structure" is not meant to be limiting as to dimension, roughness, or configuration of the substrate useful with the present invention, but rather is meant to refer to a product suitable for coating. A sheet or flat structure can refer to a substrate having either a substantially smooth or a textured appearance, e.g., a canvas-look texture.

15 "Sized paper substrate" is a paper substrate as described above that has applied to its surface and/or is saturated with a sizing composition. Sizing compositions may be applied in an internal sizing step and/or in an external sizing step; preferably sizing (e.g., internal and/or external sizing) occurs prior to application of the coating composition of the invention.

20 "Coated paper substrate" is a paper substrate that has applied to its surface and/or is saturated with a coating composition of the invention. Coating compositions may be applied as a pre-treatment (e.g., prior to printing), simultaneously with printing, or as an after-treatment. The coating compositions of the invention are applied in quantities suitable to provide the desired characteristics, such as bleed resistance, water resistance  
25 (e.g., water-fastness) of an ink printed on coated paper substrate, etc. Multiple coatings may be applied, but one embodiment consists of a single application of the coating composition on one or both sides of a substrate to produce a high quality coated paper substrate.

"Aqueous based ink" refers to an ink composed of an aqueous carrier medium (or  
30 composed of a mixed solvent medium such as a mixture of aqueous and aqueous miscible organic solvents) and a colorant, such as a dye or a pigment dispersion. An "aqueous carrier medium" is composed of water or a mixture of water and one or more water-soluble organic solvents. Exemplary aqueous based ink compositions are described in detail below.

"Colorant" as used herein is meant to encompass one or more organic dyes, inorganic dyes, pigments, stains, and the like compatible for use with the polymer coatings of the invention. A colorant may be in the RGB scale, the CMY scale, or simply a white or black opaque pigment. Examples of opaque pigments are aluminas, silicas, and titanium oxide. Examples of organic pigments are micronized organic polymers that are usually not soluble in water.

The term "organic solvent" is used herein in its conventional sense to refer to a liquid organic compound, typically a monomeric organic material in the form of a liquid, preferably a relatively non-viscous liquid, the molecular structure of which contains hydrogen atoms, carbon atoms, and optionally other atoms as well, and which is capable of dissolving solids gases or liquids.

The terms "significant" or "significantly", as when used with reference to "significantly enhanced brightness" or "significantly improved water-fastness" generally refer to a difference in a quantifiable, measurable, or otherwise detectable parameter, e.g., optical density, LAB graphs (color sphere), dot spread, bleed through, between the two groups being compared (e.g., uncoated versus coated paper substrates) that is statistically significant using standard statistical tests. For example, the degree of visual wicking or water-fastness in a coated paper substrate as detected in a print assay may be quantified using standard methods, and the degree of wicking or water-fastness under different conditions can be compared for both coated and uncoated paper substrates to detect statistically significant differences.

Photograph-like quality "look and feel", when used herein refers to a printed substrate wherein the image is substantially free of the type of speckling or graininess that is usually caused by uneven absorption (or by incomplete absorption) of water soluble inks into the substrate after printing and before drying, and may be glossy, dull or semi-glossy in appearance based upon the desired result and the desired coating composition.

The term "fluid resistance" is used herein to describe the resistance of a paper substrate to penetration by a fluid, with the term "water resistance" specifically referring to resistance of a paper substrate to penetration by a fluid.

The term "water-fast," is used herein to describe a form of water resistance, and which is normally used to refer to the nature of the ink composition after drying on a substrate. In general, "water-fast" means that the dried composition is substantially insoluble in water, such that upon contact with water, the dried ink retains at least about



70%, preferably at least about 85%, and more preferably at least about 95%, of optical density.

The term "bleed resistance" is meant to refer to the retardation of the penetration of water into paper, which retardation is associated with creation of a low energy hydrophobic surface at the fiber-water interface which increases the contact angle formed between a drop of liquid and the surface, and thus decreases the wettability. Contact angles have been shown to be sensitive to molecular packing, surface morphology, and chemical constitution of the paper substrate and any components added thereto.

The term "rub resistance" is normally meant to refer to a characteristic of the ink composition after drying on a substrate, more specifically, the ability of a printed image to remain associated with the substrate upon which it is printed despite application of force (e.g., rubbing) to the printed image. In general, "rub resistant" means that the dried ink composition is substantially resistant to rubbing force so that the dried ink retains at least about 70%, preferably at least about 85%, and more preferably at least about 95%, of optical density after rubbing of the printed image.

The term "alkyl" as used herein refers to a branched or unbranched saturated hydrocarbon group of 1 to 24 carbon atoms, such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, t-butyl, octyl, decyl, tetradecyl, hexadecyl, eicosyl, tetracosyl and the like, as well as cycloalkyl groups such as cyclopentyl, cyclohexyl and the like. The term "lower alkyl" intends an alkyl group of 1 to 6 carbon atoms, preferably 1 to 4 carbon atoms.

The term "alkylene" as used herein refers to a difunctional, branched or unbranched saturated hydrocarbon group of 1 to 24 carbon atoms, including without limitation methylene, ethylene, ethane-1,1-diyl, propane-2,2-diyl, propane-1,3-diyl, butane-1,3-diyl, and the like. "Lower alkylene" refers to an alkylene group of 1 to 6 carbon atoms.

The term "alkoxy" as used herein intends an alkyl group bound through a single, terminal ether linkage; that is, an "alkoxy" group may be defined as --OR where R is alkyl as defined above. A "lower alkoxy" group intends an alkoxy group containing 1 to 6 carbon atoms.

"Halo" or "halogen" refers to fluoro, chloro, bromo or iodo, and usually relates to halo substitution for a hydrogen atom in an organic compound.

The term "polymer" is used herein in its conventional sense to refer to a compound having about 8 or more monomer units, and unless otherwise stated, refers to a compound

having a molecular weight from about 1000 and higher. The term "oligomer" refers to a compound having from 2 to about 8 monomer units. The terms oligomer and polymer intend to cover compounds having a single type of repeating monomer unit (homopolymer or oligomer) as well as compounds containing more than one type of monomer unit (copolymers and mixed oligomers). The terms "monomer" or "monomeric" as used herein refer to compounds which are not polymeric or oligomeric as defined above.

Optionally" or "optionally" means that the subsequently described event or circumstance may or may not occur, and that the description includes instances where said event or circumstance occurs and instances where it does not. For example, the phrase "optionally substituted" aromatic ring means that the aromatic ring may or may not be substituted and that the description includes both an unsubstituted aromatic ring and an aromatic ring bearing one or more substituents.

#### Overview of the Invention

The present invention is based upon the discovery of advantages provided by an ink-jet recording medium, suitable for recording images with dye and pigmented inks, comprising a substrate coated with at least two layers comprising:

- (a) a first ink-receptive layer comprising a polymeric binder, a cross-linker and a plasticizer coated over the substrate; and
  - (b) a second layer comprising of 45 to 98% of polymeric binders where at least one binder is selected from the group consisting of:
    - (i) copolymers of hydroxyethylmethacrylate, a polymer and copolymer of vinylpyrrolidone, and
    - (ii) a fully or partially hydrolyzed polyvinyl alcohol and its derivatives, and combination thereof,
- wherein the second layer further contains at least one nitrogenous polymer, at least one non-polymeric nitrogenous compound, or a mixture thereof, wherein the nitrogenous polymer or nitrogenous compound preferably has a pKa higher than 8,

wherein said first layer is located between said second layer and the substrate in said recording medium. The ink-jet recording medium according to the invention yields high quality printed images having improved color fastness (the printed images do not run when exposed to moisture) as a result of the substantially non-reversible binding of aqueous colorants to the coating agent present in layer so coating composition(s) on the

ink-jet recording medium. These images are therefore characterized as "water-resistant" or "water-fast" due to the characteristics of the printed image following exposure to water. Often the printed images are substantially similar to the look and feel of a photographic image.

5           The coated paper substrates (ink-jet recording medium) of the invention can be used in conventional printing, or with digital printing (particularly inkjet printing, including drop-on-demand printing and continuous printing) to provide highly brilliant, printed images that are significantly improved in color quality (for example, with respect to chroma and hue) when compared to uncoated paper substrates and/or to paper substrates  
10 coated with conventional coating compositions. The coating compositions and their methods of use according to the present invention thus provide a number of advantages over conventional sizing and coating methods, and sizing and coating compositions.

          The ink-jet recording medium, methods of recording an image on such a substrate, the recording medium having an image recorded thereon, and other features of the  
15 invention are described in greater detail below.

#### **Ink-Jet Recording Medium**

          The ink-jet recording medium, suitable for recording images with dye and pigmented inks, comprising a substrate coated with at least two layers comprising:

- 20           (a) a first ink-receptive layer comprising a polymeric binder, a cross-linker and a plasticizer coated over the substrate; and
- (b) a second layer comprising of 45 to 98% of polymeric binders where at least one binder is selected from the group consisting of:
  - 25           (i) copolymers of hydroxyethylmethacrylate, a polymer and copolymer of vinylpyrrolidone, and
  - (ii) a fully or partially hydrolyzed polyvinyl alcohol and its derivatives, and combination thereof,wherein the second layer further contains at least one nitrogenous polymer, at least one non-polymeric nitrogenous compound, or a mixture thereof, wherein the nitrogenous polymer or nitrogenous compound  
30           preferably has a pKa higher than 8,

wherein said first layer is located between said second layer and the substrate in said recording medium.

The coating layers of the invention can be readily prepared from commercially available starting materials and/or reagents, are compatible with additional binders or additives, can be used with a variety of base papers, and are compatible with a variety of printing methods, including conventional and digital printing methods (particularly inkjet printing, including drop-on-demand printing and continuous printing), and can also be used with existing commercial paper production processes and equipment. The coating composition for each of the two layers of the ink-jet recording medium are inexpensive to prepare, and relatively small amounts are required to provide an ink-jet recording medium having the advantageous features described herein. The coating compositions used for each of the two layers of the ink-jet recording medium of the invention are also easy to handle due to their solubility in water (the active components, the coating agents, are hydrophilic polymers), and do not require the use of large volumes of organic solvents. Such coating compositions also possess good film-forming properties.

The ink-jet recording medium is a coated paper substrate prepared as described herein which exhibits improved durability, as evidenced by improved paper strength (e.g., tear strength), and stability upon prolonged storage. The ink-jet recording medium does not discolor or yellow, and maintains a high degree of brightness for extended periods of time. Paper substrate ink-jet recording mediums according to the invention react rapidly and, in some embodiments, irreversibly with a number of aqueous based colorants, thus providing a versatile coating system for use with a wide variety of available colorants. Furthermore, because the colorant reacts quickly with the layers of coating compositions, the recorded ink-jet recording medium does not require a separate curing step, but rather is fast-drying. This fast-drying characteristic provides for printed images that are "non-sticky," thus allowing the ink-jet recording medium to be handled immediately after printing, e.g., to allowing stacking. The ink-jet recording medium of the invention can also be used to prepare images with varying degrees of gloss, depending upon variations in pigment.

In addition to their water resistance, ink-jet recording medium paper substrates according to the invention are highly bleed-resistant (as evidenced by small dot size measurements, i.e., less wicking action) and rub-resistant.

Embodiments of the present invention are described as follows.

In one embodiment the invention provides an ink-jet recording medium, suitable for recording images with dye and pigmented inks, comprising a substrate coated with at least two layers comprising:

- 5 (a) a first ink-receptive layer comprising a polymeric binder, a cross-linker and a plasticizer coated over the substrate; and
  - (b) a second layer comprising of 45 to 98% of polymeric binders where at least one binder is selected from the group consisting of:
    - (i) copolymers of hydroxyethylmethacrylate, a polymer and copolymer of vinylpyrrolidone, and
    - 10 (ii) a fully or partially hydrolyzed polyvinyl alcohol and its derivatives, and combination thereof,wherein the second layer further contains at least one nitrogenous polymer, at least one non-polymeric nitrogenous compound, or a mixture thereof, wherein the nitrogenous polymer or nitrogenous compound has a
  - 15 pKa higher than 8,
- wherein said first layer is located between said second layer and the substrate in said recording medium.

In a preferred embodiment of such an ink-jet recording medium, the nitrogenous

20 polymer or compound preferably having a pKa higher than 8 is a member selected from the group consisting of:

- (i) polyhexylmethylbiguanidine or a salt thereof,
- (ii) polyvinylamidine or a salt thereof,
- (iii) chlorhexidine or a salt thereof, and
- 25 (iv) a mixture of 2 or more of (i)-(iii).

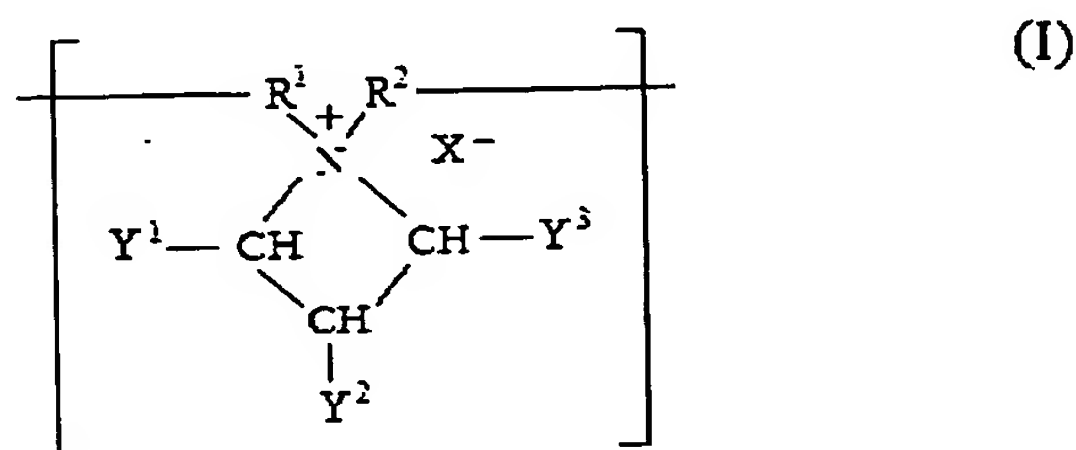
Further preferred is such an ink-jet recording medium wherein the salt of the basic nitrogenous moiety of the dye-fixing compound or polymer is formed of a cation with a counter ion selected from the group consisting of an organic or inorganic anion. More preferred is such an ink-jet recording medium wherein the anion of the salt is a member

30 selected from the group consisting of halide, hydrogen sulfate, acetate, methane sulfonate, succinate, citrate, malonate, fumarate, oxylate, gluconate or a gluconate derivative. Still further preferred is such an ink-jet recording medium, wherein the anion of the salt is gluconate or a gluconate derivative.



In one embodiment of the invention the above described ink-jet medium includes in the first layer (a) as a cross-linker an azetidinium polymer or salt thereof. In one such preferred embodiment the azetidinium polymer or salt thereof is a homopolymer or salt thereof. In another such preferred embodiment the azetidinium polymer or salt thereof is a  
 5 copolymer or salt thereof.

In a particularly preferred embodiment, the azetidinium polymer salt is comprised of monomer units having the structural formula:



in which  $\text{R}^1$  and  $\text{R}^2$  are independently lower alkylene,  $\text{X}^-$  is an anionic, organic or inorganic counterion, and  $\text{Y}^1$ ,  $\text{Y}^2$  and  $\text{Y}^3$  are selected from the group consisting of  
 10 hydrogen, hydroxyl, halo, alkoxy, alkyl, amino, carboxy, acetoxy, cyano and sulfhydryl.

Particularly preferred is such an ink-jet recording medium, wherein the  $\text{X}^-$  anion of the salt is an anion of an organic acid. Further the  $\text{X}^-$  anion of the salt is a member  
 15 selected from the group consisting of halide, hydrogen sulfate, acetate, methane sulfonate, succinate, citrate, malonate, furarate, oxylate, gluconate or a gluconate derivative.

Preferred azetidinium polymers comprise such monomeric units wherein  $\text{R}^1$  and  $\text{R}^2$  are methylene,  $\text{Y}^1$  and  $\text{Y}^3$  are independently hydrogen or lower alkyl, and  $\text{Y}^2$  is hydrogen or hydroxyl. More preferred such azetidinium polymers are wherein  $\text{Y}^1$  and  $\text{Y}^3$  are both  
 20 hydrogen, and  $\text{Y}^2$  is hydroxyl.

A preferred ink-jet recording medium according to the invention is wherein the first and second layers comprise polymers that are soluble in an aqueous solvent or are soluble in a solvent mixture of an aqueous solvent and a polar organic solvent. A particularly preferred polar organic solvent is an alcohol.

A further preferred such ink-jet recording medium as described above is wherein  
 25 the second layer contains at least one polymer that is soluble in an aqueous solvent or in a solvent mixture of an aqueous solvent and a polar organic solvent and the polymer is a member selected from a group hydroxyethylmethacrylate copolymer or terpolymer, or a

derivative thereof, wherein the copolymer or terpolymer comprises at least one member of the group consisting of 2-hydroxyethylmethacrylate/co-acrylic acid copolymer, 2-hydroxyethylmethacrylate/methacrylic acid copolymer, 2-hydroxyethylmethacrylate/dimethylaminopropylmethacrylate, 2-hydroxyethylmethacrylate/dimethylaminoethylmethacrylate, and 2-hydroxyethylmethacrylate-vinylpyrrolidone, quaternized polyhydroxyethylmethacrylate-co-dimethylaminopropylmethacrylate, quaternized polyhydroxyethylmethacrylate-co-dimethylaminoethylmethacrylate; Vinylpyrrolidone polymers and copolymers are selected from the group consisting polyvinylpyrrolidone vinylpyrrolidone/dimethylaminoethyl methacrylate copolymer, vinyl caprolactam/vinylpyrrolidone/dimethylaminoethyl methacrylate terpolymer, vinylcaprolactam/vinylpyrrolidone/dimethylaminopropyl methacrylamide terpolymer, vinylpyrrolidone/dimethylaminopropyl methacrylamide copolymer, vinylpyrrolidone/dimethylaminoethyl methacrylate copolymer, and quaternized derivatives thereof.

15 A particularly preferred ink-jet recording medium is wherein the second layer contains at least one polymer that is soluble in an aqueous solvent or in a solvent mixture of an aqueous solvent and a polar organic solvent as described above, wherein the concentration of the polyhexymethylbiguanidine and its salts in combination in the second layer (b) is from about 1% to about 5% by weight of the dry coat weight of the second layer. More preferred is wherein the first layer comprises at least one member selected from the group consisting of partially or fully hydrolysed polyvinyl alcohol and their derivatives, HEMA copolymers as described above, vinylpyrrolidone polymers and copolymers and cationic polyurethane and a mixture of at least two members thereof.

25 In one embodiment of such an ink-jet recording medium, the first layer composition further contains at least one cross-linker selected from group of polyamide-epichlorhydrin resin and polyfunctional aziridine or mixture thereof. Preferably, the first layer composition contains an azetidinium compound, or salt thereof, as a polyamide-epichlorhydrin cross-linker.

30 Another embodiment of the ink-jet recording medium according to the invention is wherein each of the first and second layers may independently include a plasticizer which is a member selected from the group consisting of phosphates, substituted phthalic anhydrides, glycerols, and polyglycols. A preferred plasticizer is polyethylene glycol or a derivatives thereof.

In another embodiment according to the invention the second layer of the ink-jet recording medium further comprises a white pigment.

The second layer of the ink recording medium according to the invention can further comprise organic particulates selected from the group consisting of starch,  
5 polyolefins, poly(methyl methacrylates), polystyrenes, polytetrafluoroethylenes, and polyurethanes. Also, the second layer can further comprise additives selected from the group consisting of antifoam agents, surfactants, dyestuffs, optical brighteners, and mixtures thereof.

A preferred ink-jet recording medium of the invention is wherein the substrate is a  
10 paper or polymeric film. A preferred substrate is a paper selected from the group consisting of plain, clay-coated, resin-coated, and latex-saturated papers. Another preferred substrate is a polymeric film selected from the group consisting of polyvinyl chloride, polyethylene, polypropylene, polycarbonate, polyimide, polyester, and fluoroplastic films.

15 In one preferred embodiment, the inkjet recording medium comprises a coated substrate that is glossy and opaque, transparent, translucent, matte, or non-glossy opaque.

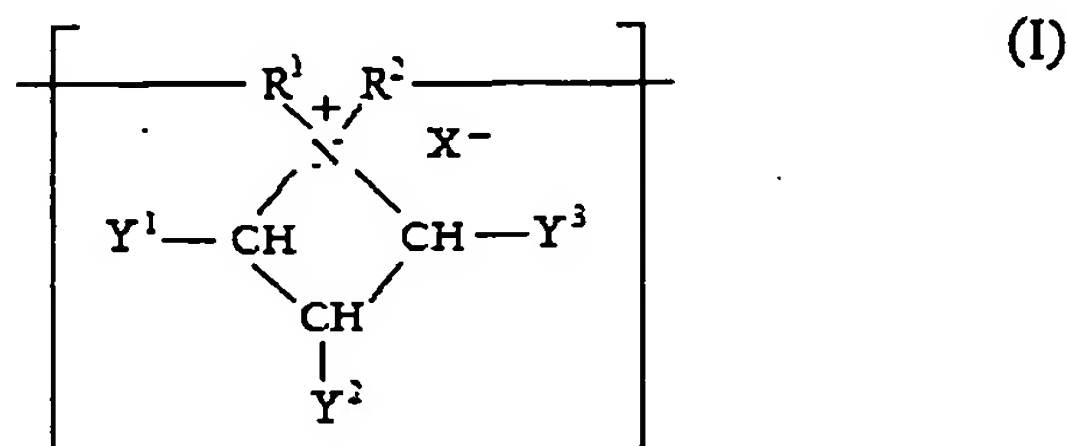
The inkjet recording medium of the present invention may comprise a substrate wherein one or more functional or non-functional coating layers are placed between the paper substrate and two coating layers (a) and (b).

20 In one embodiment the present invention provides a method for providing a water-resistant image on the ink-jet recording medium of the invention as described above, comprising applying an ink composition to the recording medium, wherein the ink composition comprises a dye having ionizable and/or nucleophilic groups capable of reacting with a dye-fixing compound. A preferred such method is wherein the dye  
25 composition is a predominantly aqueous based ink or is an ink having a mixed solvent of at least one aqueous solvent and at least one aqueous miscible organic solvent.

In one embodiment, the invention provides a printed paper product prepared by the method described above. A preferred printed paper product prepared by the above method is wherein one surface of the paper has an adhesive backing that is optionally removable.

30 Structures and description of structures in the ink-receptive surface coating composition of layers (a) and (b) are described as follows:

A. In one embodiment of the invention, the azetidinium polymer salt is comprised of monomer units having the structural formula I:



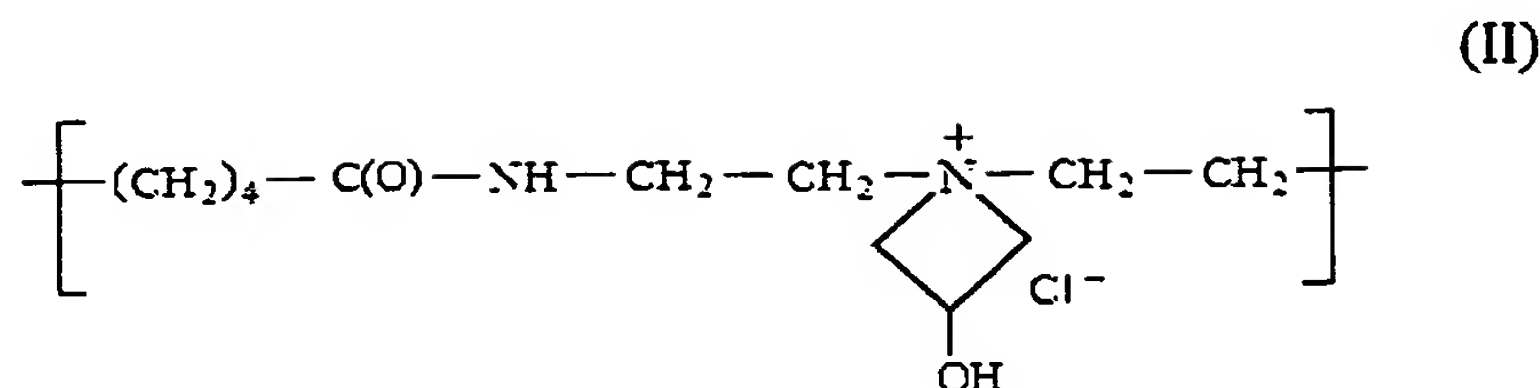
in which  $\text{R}^1$  and  $\text{R}^2$  are independently lower alkylene,  $\text{X}^-$  is an anionic, organic or inorganic counterion, and  $\text{Y}^1$ ,  $\text{Y}^2$  and  $\text{Y}^3$  are selected from the group consisting of hydrogen, hydroxyl, halo, alkoxy, alkyl, amino, carboxy, acetoxy, cyano and sulfhydryl. Preferably the the  $\text{X}^-$  anion of the salt is an anion of an organic acid, and more preferably the  $\text{X}^-$  anion of the salt is the anion of an alkanoyl group. Even more preferably, the  $\text{X}^-$  anion of the salt is a member selected from the group consisting of halide, hydrogen sulfate, acetate, methane sulfonate, succinate, citrate, malonate, fumarate, oxylate, gluconate or a gluconate derivative, and further preferred the anion of the salt is gluconate or a gluconate derivative.

Preferably, in the Formula I azetidinium polymer structure,  $\text{R}^1$  and  $\text{R}^2$  are methylene,  $\text{Y}^1$  and  $\text{Y}^3$  are independently hydrogen or lower alkyl, and  $\text{Y}^2$  is hydrogen or hydroxyl. More preferred are such structures wherein  $\text{Y}^1$  and  $\text{Y}^3$  are both hydrogen, and  $\text{Y}^2$  is hydroxyl.

In another embodiment, the coating agent in the above described process comprises a guanidine polymer or a salt thereof. The guanidine polymer or salt thereof is a member selected from a homopolymer or a salt thereof and a copolymer or a salt thereof.

The azetidinium polymer may be a homopolymer, or it may be a copolymer, wherein one or more non-azetidinium monomer units are incorporated into polymer structure. Any number of comonomers may be employed to form suitable azetidinium copolymers for use herein; however, a particularly preferred azetidinium copolymer is aminoamide azetidinium. Further, the azetidinium polymer may be essentially straight-chain or it may be branched or crosslinked.

B. A preferred azetidinium polymer for use in the present invention is shown in Formula (II)

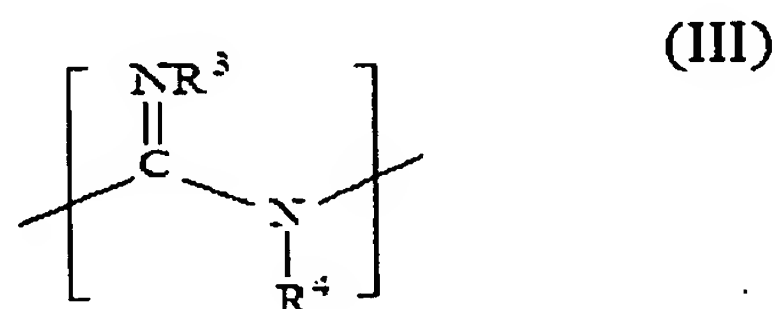


Commercially available such polymers include "AMRES.RTM.," available from Georgia Pacific, Resins, Inc., Atlanta, Ga., "KYMENE.RTM.," from Hercules, Inc., Wilmington, Del., and "Polycup.RTM.," also from Hercules, Inc. These azetidinium polymers are generally referred to as poly(aminoamide)-epichlorohydrin (PAE) resins; such resins are typically prepared by alkylating a water-soluble polyamide containing secondary amino groups with epichlorohydrin. Other suitable azetidinium polymers will be known to those skilled in the art and/or are described in the pertinent texts, patent documents, and literature references; see, for example, Moyer, et al., in Wet Strength in Paper and PaperBoard, Tappi Monograph Series No. 29, Tappi Press, Ch. 3, p. 33-37 (1965); Chan, in Tappi Wet and Dry Strength Short Course, Tappi Press, Atlanta, Apr. 13-15, 1988; and Espy, in Wet Strength Resins and Their Application, Ed., Lock L. Chan, Tappi Press, Atlanta, Ga. (1994).

#### (B) Guanidine Polymers

In another embodiment, the coating agents in the second layer may include a guanidine polymer or a salt thereof, also termed a "polyguanidine" or a "polyhexylmethylbiguanidine." The guanidino group is extremely basic, possessing a pKa of about 12-13. Polyguanidine and polyhexylmethylbiguanidine polymers for use in the invention are typically provided as acid salts wherein the imine nitrogen atoms are for the most part in a protonated form and are cations.

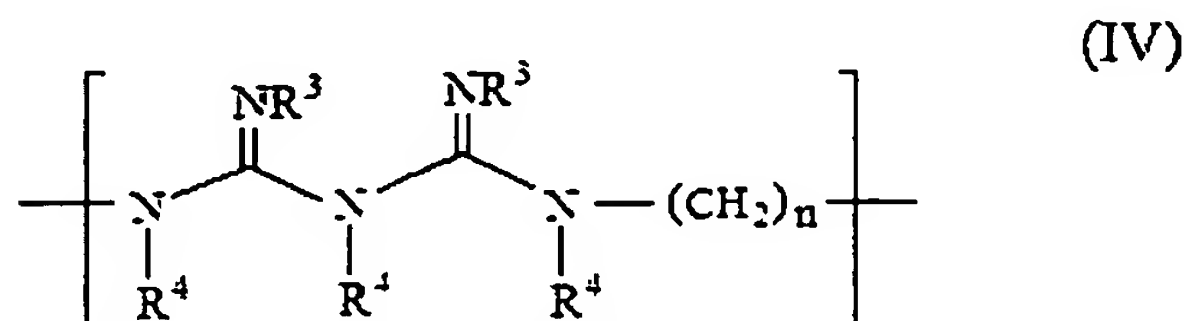
In general, guanidine polymers and polyhexylmethylbiguanidines useful as coating agents in the present invention are either homopolymers or copolymers. All guanidine polymers herein are comprised of recurring monomer units having the structural formula





wherein  $R^3$  is hydrogen or lower alkyl and  $R^4$  is hydrogen, alkyl, alkoxy, or hydroxyl-substituted alkoxy. Preferably,  $R^3$  and  $R^4$  are hydrogen.

Particularly preferred guanidine polymers for use herein are comprised of monomer units having the structural formula (IV)



5

wherein  $n$  is an integer in the range of 1 to 10 inclusive,  $R^3$  is hydrogen or lower alkyl and  $R^4$  is hydrogen, alkyl, alkoxy, or hydroxyl-substituted alkoxy. Preferably,  $R^3$  and  $R^4$  are hydrogen. Preferred structures of formula IV are wherein  $n$  is 6 and the compound is a polyhexylmethylbiguanadine polymer.

10

A particularly preferred guanidine polymer for use in the methods and compositions of the invention has the structure of formula (IV) wherein  $R^3$  and  $R^4$  are H and  $n$  is 6 (3,12-diimino-2,4,11,13-tetraazatetradecanediimidamide), available commercially as "BAQUACIL.RTM." and "VANTOCIL.RTM.," from Zeneca, Inc.

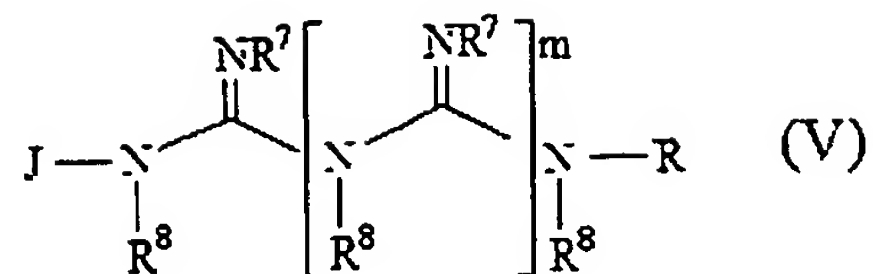
15 Guanidine polymers of the invention react electrostatically with anionic groups present in the dye via ion-exchange type interactions, to rapidly and irreversibly bind anionic type dyes to print substrates coated with such polymers.

#### C. Guanidine Oligomers and Other Guanidine Derivative Compounds

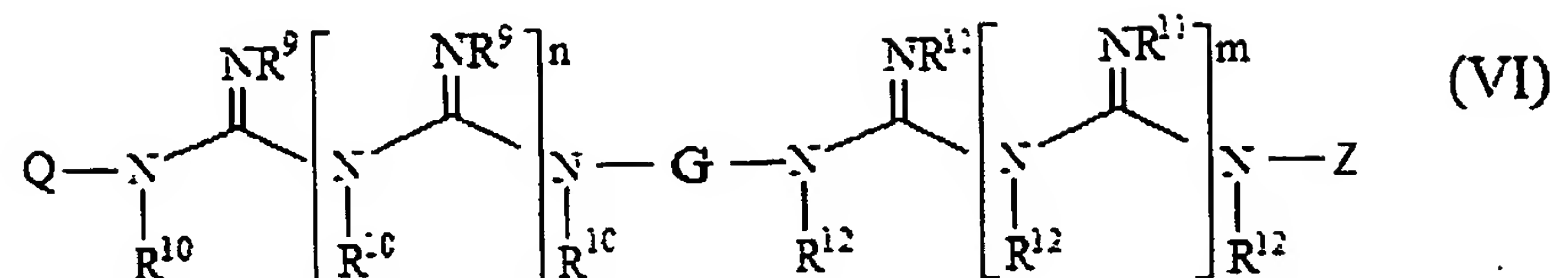
In another embodiment, the coating agents in the first or second layers may include a guanidine oligomer or a salt thereof, or a guanidine derivative compound. The  
20 guanidino portion of such compounds can be very basic, possessing a  $pK_a$  of up to about 12-13. Such compounds are typically provided as acid salts wherein the imine nitrogen atoms are for the most part in a protonated form and are cations.

Examples of guanidine oligomers or other guanidine derivative compound are each a member selected from the group consisting of Formula V or Formula VI:

25



and



wherein,

k, n and m are each independently an integer from 0-4,

5 J, Q and Z are each independently a monocarbocyclic or bicyclic carbocyclic aromatic group which can be substituted by 1 to 5 members selected from the group consisting of hydrogen, hydroxyl, halo, alkoxy, alkyl, amino, carboxy, acetoxy, cyano and sulfhydryl,

10 G is a bivalent C<sub>1</sub>-C<sub>12</sub> straight or branched chain alkyl, alkenyl or alkynyl linking group which can be substituted in the carbon chain by 1 to 4 members selected from the group consisting of O, S, N atoms and 1-12 of the hydrogen atoms on the carbon chain may be replaced independently by a member selected from the group consisting of hydroxyl, halo, alkoxy, alkyl, amino, carboxy, acetoxy, cyano and sulfhydryl,

15 R is a C<sub>1</sub>-C<sub>12</sub> straight or branched chain alkyl, alkenyl, alkynyl or alkanoyl group, and 1-12 of the hydrogen atoms on the carbon chain may be replaced independently by a member selected from the group consisting of hydroxyl, halo, alkoxy, alkyl, amino, carboxy, acetoxy, cyano and sulfhydryl,

R<sup>7</sup>, R<sup>9</sup> and R<sup>11</sup> are each independently hydrogen or lower alkyl, and

20 R<sup>8</sup>, R<sup>10</sup> and R<sup>12</sup> are each independently hydrogen, alkyl, alkoxy or hydroxyl-substituted alkyl,

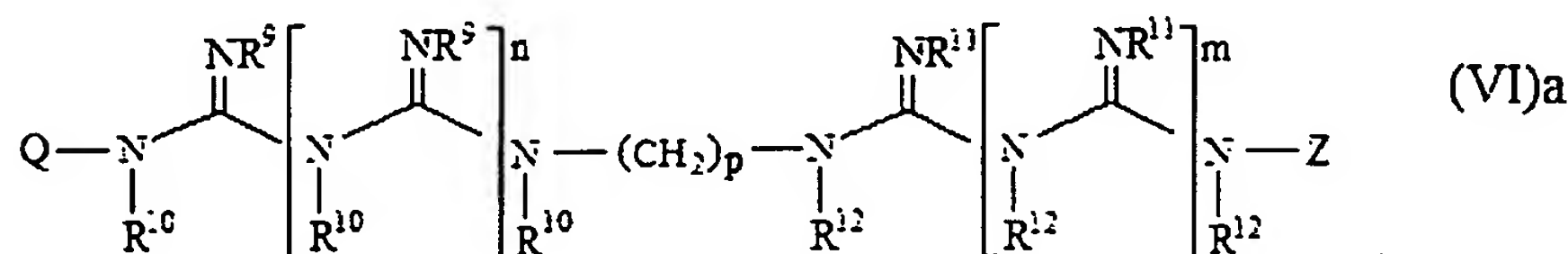
or a salt thereof.

A preferred agent for the coating layers is an effective amount of chlorhexidine, or a salt thereof as the ink receptive surface coating composition or agent. Some examples of the chlorhexidine salts are the dihydrochloride salt that is sold under the brand name Lisium, the diacetate salt that is sold under the brand name Chlorasept 2000, and the  
 5 chlorhexidine digluconate salt that is sold under brand names such as Bacticlens, Corsodyl, Hibiclens, Hibidil, Hibiscrube, Hibitane, Orahexal, Peridex and the like. A particularly preferred chlorhexidine salt is the chlorhexidine digluconate salt.

Preferred salts of such compounds are wherein the anion of the salt is an anion of an organic acid. Particularly preferred anion groups are alkanoyl groups, in particular  
 10 when the anion group is gluconate or a gluconate derivative. General examples of anion groups are halide, hydrogen sulfate, acetate, methane sulfonate, succinate, citrate, malonate, furarate, oxylate, gluconate or a gluconate derivative.

Preferred compounds of Formula V and Formula VI as described above are compounds, wherein each of J, Q and Z is a member selected from the group consisting of  
 15 phenyl substituted by 1 to 3 members selected from the group consisting of hydrogen, hydroxyl, halo, alkoxy, alkyl, amino, carboxy, acetoxy, cyano and sulfhydryl, and n and m are each the integer 1, or a salt thereof.

One preferred embodiment of are such compounds as described above is a group of compounds have the following formula:



20

wherein each of Q and Z is a member selected from the group consisting of phenyl substituted by 1 to 3 members selected from the group consisting of hydrogen, hydroxyl, halo, alkoxy, alkyl, amino, carboxy, acetoxy, cyano and sulfhydryl, and

25 p is an integer from 1-20,

or a salt thereof.

Preferred are such compounds wherein each of R<sup>9</sup>, R<sup>10</sup>, R<sup>11</sup> and R<sup>12</sup> is hydrogen, p is an integer from 4-8, and each of Q and Z is a phenyl group substituted in the para position by a halo group, or a salt thereof. More preferred are such compounds wherein

each of Q and Z is a phenyl group substituted in the para position by a chloro group, p is the integer 6, or a salt thereof.

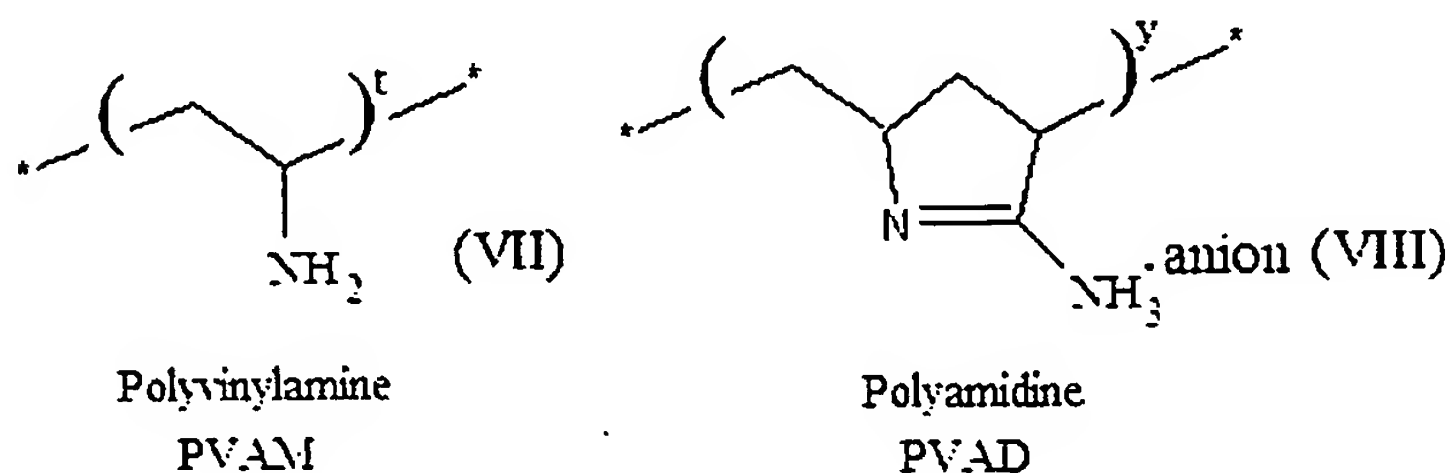
Another preferred embodiment is the group of compounds of formula V as described above are compounds wherein each of R<sup>7</sup> and R<sup>8</sup> is hydrogen, J is a phenyl group substituted in the para position by a halo group, and R is a member selected from the group consisting of a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, a t-butyl group, an n-pentyl group, an amyl and an isoamyl group, k is the integer 1, or a salt thereof. More preferred are such compounds wherein J is a phenyl group substituted in the para position by a chloro group, and R is an isopropyl group, or a salt thereof.

An example of a compound according to formula V is chlorguanide, also known by the names Diguanyl, Drinupal, Guanatol, Palusil and the like (see the Merck Index of Organic Compounds at Compound 2088). The hydrochloride salt has the brand name Paludrine and is useful in commerce as an antimalarial agent. Particularly preferred for the present invention is a glutarate or a glutarate derivative salt of chlorguanide.

#### D. Other nitrogenous compounds useful in the present invention.

Examples of other such compounds are polyvinylamidine (PVAD) and polyvinylamine (PVAM) compounds. Esprit Chemicals, [www.espritchem.com](http://www.espritchem.com) (Tele. 941-355-5100, 1-800-237-7748, fax 941-358-1339) provides two vinylamide type polymers PVAM-0595B, a homopolymer of vinyl amine and PVAD-L, a copolymer of vinyl amine and acrylonitrile. Preferred compounds are the alkanoyl salts of these polymers such as gluconate or gluconate derivative salts. The PVAM and PVAD polymers tend to form amides when reacted with acids and may be utilized in the present invention.

Examples of PVAM and PVAD polymeric structures are shown below.



Nitrogenous compounds having similar properties to the above compounds may be utilized in the present invention.

In one embodiment the polymeric binder is a film-forming binder selected from the group consisting of polysaccharides, polypeptides, synthetic vinyl polymers, cationic film-forming binders, and derivatives thereof. Preferred polysaccharide binders are selected from the group consisting of starch, a cellulosic polymer, dextran and the like. Preferred polypeptide binders are selected from the group consisting of collagen and gelatin. Preferred synthetic film-forming binders are a member selected from the group consisting of a synthetic vinyl polymer or polyethyloxazoline monomer units. Preferred synthetic vinyl polymers are selected from the group consisting of poly(vinyl alcohol), poly(vinyl phosphate), poly(vinyl pyrrolidone), vinyl-pyrrolidone-vinyl acetate copolymers, vinyl acetate-acrylic acid copolymers, vinyl alcohol-vinyl acetate copolymers, vinyl pyrrolidone-styrene copolymers, poly(vinylamine) and polyethyloxazoline, or a quaternary salt thereof. A more preferred synthetic vinyl polymer binder is a vinyl pyrrolidone-styrene copolymer or quaternary salts thereof.

Preferred film forming binders comprise at least one cationic film-forming binder. More preferred cationic film-forming binders are quaternized members selected from the group consisting of a vinyl pyrrolidone-dimethylaminoethylmethacrylate copolymer, dimethyl-aminoethylmethacrylate-co-methyl methacrylate, 2-hydroxyethylmethacrylate-dimethyl-aminoethylmethacrylate, 2-hydroxypropylmethacrylate-dimethylaminoethylmethacrylate, polydiallyldimethyl ammonium chloride and quaternized aminoacrylate polymers. Even more preferred is the cationic film-forming binder which is a salt having as the anion counter-ion a member selected from the group consisting of halide, hydrogen sulfate, acetate, methane sulfonate, succinate, citrate, malonate, fumarate, oxylate, gluconate or a gluconate derivative. Most preferred is where such cationic film-forming binder salts have the anion of the salt as gluconate or a gluconate derivative.

In one embodiment the coating composition according to the invention further includes a colorant or pigment, particularly silicas, aluminas, titanium dioxide, and the like. The colorant or pigment can be a white or black opaque pigment.

In a preferred embodiment of the invention, the ink receptive coating composition or agent represents approximately 2 wt. % to 55 wt. % of the coating composition, based upon total solids weight of the composition after drying.



In one embodiment the present invention provides an ink-jet recording medium which is an optionally pre-sized paper product coated by coating composition as described above wherein the ink receptive surface coating agent or composition comprises a member selected from the group consisting of chlorhexidine or a salt thereof, chlorguanide or a salt thereof, polyvinyl amidine (PVAD) or a salt thereof, or mixtures of two or more of these. In a more preferred embodiment, the optionally pre-sized paper product is coated with a coating composition comprising a gluconate or gluconate salt of a compound selected from the group consisting of Formula I, Formula II, Formula III, Formula IV, Formula V, Formula VI, Formula VII, Formula VIII, or mixtures of two or more of these.

The various components of the coating composition will now be described.

#### 1. Coating Agents for coated layers

The coating agents are as described above. In some embodiments of the invention, it is important that the pH of the coating composition be acidic, as some compositions can tend to gel at basic pH. In such cases, if necessary, an acid should be added to the composition to ensure that the pH is below 7.0, preferably less than about 6.5, and most preferably in the range of about 1.0 to 6.5. Suitable acids include sulfuric acid, hydrochloric acid, acetic acid, and the like.

#### 2. Film-Forming Binders

The coating compositions in the layers of the invention recording medium preferably include a film-forming binder. By "film-forming binder" is meant a substance that provides for improved strength of a paper substrate upon application of the substance to the substrate. "Film-forming binders" used in connection with the coating compositions of the invention include any film-forming binder that is compatible with the selected coating agent and other components of the coating composition. Exemplary film-forming binders include, but are not necessarily limited to: polysaccharides and derivatives thereof, e.g., starches, cellulosic polymers, dextran and the like; polypeptides (e.g., collagen and gelatin); and synthetic polymers, particularly synthetic vinyl polymers such as poly(vinyl alcohol), poly(vinyl phosphate), poly(vinyl pyrrolidone), vinyl-pyrrolidone-vinyl acetate copolymers, vinyl alcohol-vinyl acetate copolymers, vinyl pyrrolidone-styrene copolymers, and poly(vinyl amine), and cationic film-forming binders such as quaternized vinyl pyrrolidone-dimethylaminoethyl-methacrylate copolymer, dimethylaminoethyl-

methacrylate-co-methyl methacrylate, polydiallyldimethyl ammonium chloride and quaternized aminoacrylate polymers.

Polysaccharide binders: Starches, as noted above, represent one category of suitable film-forming binders for use herein. Suitable starches may be any of a variety of natural, converted, and synthetically modified starches. Exemplary starches include, but are not necessarily limited to starch (e.g., SLS-280 (St. Lawrence Starch)), cationic starches (e.g., Cato-72 (National Starch), hydroxyalkylstarch, wherein the alkyl has at least one carbon atom and wherein the number of carbon atoms is such that the material is water soluble, preferably from about 1 to about 10 carbon atoms, such as methyl, ethyl, propyl, butyl, or the like (e.g., hydroxypropyl starch #02382 (PolySciences, Inc.), hydroxyethyl starch #06733 (PolySciences, Inc.), Penford Gum 270 and 280 (Penford), and Film-Kote (National Starch)), starch blends (see, e.g., U.S. Pat. No. 4,872,951, describing a blend of cationic starch and starch treated with an alkyl or alkenyl succinic anhydride (ASA), preferably 1-octenyl succinic anhydride (OSA)), and the like. The film-forming binder can also be a synthetically produced polysaccharide, such as a cationic polysaccharide esterified by a dicarboxylic acid anhydride (see, e.g., U.S. Pat. No. 5,647,898). Additional saccharide binders include cellulosic materials such as alkyl celluloses, aryl celluloses, hydroxy alkyl celluloses, alkyl hydroxy alkyl celluloses, hydroxy alkyl celluloses, dihydroxyalkyl cellulose, dihydroxyalkyl cellulose, hydroxy alkyl hydroxy alkyl cellulose, halodeoxycellulose, amino deoxycellulose, dialkylammonium halide hydroxy alkyl cellulose, hydroxyalkyl trialkyl ammonium halide hydroxyalkyl cellulose, dialkyl amino alkyl cellulose, carboxy alkyl cellulose salts, cellulose sulfate salts, carboxyalkylhydroxyalkyl cellulose and the like). Still additional film-forming binders of this type include dextran (e.g., dialkyl aminoalkyl dextran, amino dextran, and the like), carrageenan, Karaya gum, xanthan, guar and guar derivatives, (e.g., carboxyalkyl hydroxyalkyl guar, cationic guar, and the like), and gelatin.

Additional exemplary film-forming binders include resins (e.g., such as formaldehyde resins such as melamine-formaldehyde resin, urea-formaldehyde resin, alkylated urea-formaldehyde resin, and the like), acrylamide-containing polymers (e.g., poly(acrylamide), poly(N,N-dimethyl acrylamide), and the like), poly(alkyleneimine)-containing polymers (e.g., poly(ethyleneimine), poly(ethyleneimine)epichlorohydrin, alkoxyated poly(ethyleneimine), and the like), polyoxyalkylene polymers (e.g., poly(oxymethylene), poly(oxyethylene), ethylene oxide/propylene oxide copolymers, ethylene oxide/2-hydroxyethyl methacrylate/ethylene oxide and ethylene

oxide/hydroxypropyl methacrylate/ethyleneoxide triblock copolymers, ethylene oxide-4-vinyl pyridine/ethylene oxide triblock copolymers, ethylene oxide-isoprene/ethylene oxide triblock copolymers, epichlorohydrin-ethylene oxide copolymer, and the like), etc. Other examples are film forming binders comprising 2-hydroxyethylmethacrylate copolymer or  
5 terpolymer, or a derivative thereof.

Examples of 2-hydroxyethylmethacrylate copolymer or terpolymer, or a derivative thereof, are wherein the copolymer or terpolymer is at least one member of the group consisting of 2-hydroxyethylmethacrylate/co-acrylic acid copolymer, 2-hydroxyethylmethacrylate/meth-acrylic acid copolymer, 2-hydroxyethyl-  
10 methacrylate/dimethylaminopropylmethacrylate, 2-hydroxyethylmethacrylate/dimethyl-aminoethylmethacrylate, and 2-hydroxyethylmethacrylate-vinylpyrrolidone, and the like.

Such film forming binders can further comprise at least one additional film forming binder selected from the group consisting of (a) polyvinyl alcohol or a copolymers comprising vinyl alcohol monomer units, (b) polyvinylpyrrolidone or a  
15 copolymer comprising vinylpyrrolidone monomer units, (c) cellulose or a cellulose derivative, (d) starch or a starch derivative, (e) a vinyl acetate polymer or a copolymer comprising vinyl acetate monomer units, and (f) polyethyloxazolidine, or a quaternized derivative thereof.

Any of the above exemplary film-forming binders can be used in any effective  
20 relative amounts, although typically the film-forming binder, if present in the proportions as described above in the description of the coating composition proportions. Starches and latexes are of particular interest because of their availability and applicability to paper.

### 3. Other Coating Composition Components

25 Additional coating composition components in each of the two layers for the ink-jet recording medium according to the invention may include, but are not necessarily limited to, inorganic fillers, anti-curl agents, or additional conventional components such as a surfactant, plasticizer, humectant, UV absorber, light fastness enhancer, polymeric dispersant, dye mordant, optical brightener, or leveling agent, as are commonly known in  
30 the art. Illustrative examples of such additives are provided in U.S. Pat. Nos. 5,279,885 and 5,537,137. Of particular interest is the inclusion of additional components that provide for a coated substrate having a non-glossy, matte, or glossy surface; as will be appreciated by those skilled in the art, incorporation of a pigment (e.g., silica, calcium carbonate) will generally give rise to a non-glossy surface, while a glossy surface will

result in the absence of a pigment (or in the presence of only a small amount of pigment), provided that the underlying substrate surface has a glossy finish at the outset (e.g., is resin coated or the like).

5 Examples of coating composition are compositions as described above, wherein:

(a) the organic cross-linking agent, when present, is at least one member of the group consisting of an polyamide-epichlorhydrin resin, an epoxy resin composition, a polyfunctional azridine compound, an azeridinium compound, and the like, and

10 (b) the inorganic cross-linking agent, when present, is a member selected from the group consisting of a zirconium compound and boron compounds, and the like.

Preferred are such coating compositions, wherein the polyamide-epichlorhydrin resin is an azetidinium resin, the zirconium compound is ammonium zirconium carbonate, and the boron compound is boric acid.

15 In one preferred embodiment, the coating compositions for each of the two layers as described above are coating compositions in an aqueous solvent or in a mixed solvent of at least one aqueous solvent and at least one aqueous miscible organic solvent.

The coating compositions for each of the two layers may also contain a colorant, e.g., a pigment, dye or other colorant, to provide for whiteness or color of the coated paper substrate. The coating compositions may also further include a cross-linking agent, such as zirconium acetate, ammonium zirconium carbonate, or the like, for intra-molecular and/or intermolecular cross-linking of coating agents in the coating composition, and/or a chelating agent such as boric acid. Additional components that may be desirable for use in the coating compositions of the invention, as well as guidance for the use of such components and a general description of paper chemistry, are found in Paper Chemistry, 2nd Edition, Roberts, ed., Blackie Academic & Professional, Glasgow, UK (1994). For example, surfactants, leveling agents, and de-foaming agents may also be utilized in the coating compositions.

25 The coating compositions for each of layers (a) and (b) are preferably provided in an aqueous liquid vehicle, that only contains small amounts of a water-soluble organic solvent may be present. However, the aqueous liquid vehicle (generally water) may contain other non-organic compounds which are water soluble (smaller amounts) or water miscible. It may on occasion be necessary to add a solubilizing compound during

preparation of the coating composition so that the components dissolve in the aqueous liquid vehicle, e.g., an inorganic base such as ammonia and/or an organic amine. Suitable organic amines include lower alkyl-substituted amines such as methylamine, dimethylamine, ethylamine, and trimethylamine, as well as ethanolamine, diethanolamine, triethanolamine, and substituted ethanolamines, typically lower alkyl-substituted ethanolamines such as N-methyl and N,N-dimethyl ethanolamines, and morpholine. Such compounds are also useful for bringing the pH into the desired range for basic formulations, and, if present, will generally represent not more than about 20 wt. % of the composition, and in most cases will represent not more than about 10 wt. % of the composition.

#### Application of Coating Compositions to Paper Substrates

The coating compositions for each of layers (a) and (b) of the ink-jet recording medium according to the invention can be applied to a substrate, e.g., a paper substrate, by any of a number of conventional processes commonly employed in the art. The substrate as defined above can be made of natural or synthetic fibers or of simply pressed or molded solids, in addition sheets of substrate can be woven such as in fabric or canvas, and can optionally be a coated substrate prior to use of the present coating composition. In essence, the base stock or fibrous cellulosic substrate to be coated in accordance with the present invention can be one of a wide variety of types depending upon the intended use of the final product. The paper substrate is optionally pre-sized, either internally or externally, and can vary in weight from lightweight papers to the heavier paperboards. However, where the coating is applied on-machine, in order to achieve acceptable manufacture speeds (e.g., 100 to 3000 ft./per minute), it is recommended that the weight of the paper base be greater than 30 grams per square meter. When the final product is to exhibit gloss at a satisfactory level (generally greater than 50), the base sheet, before it receives the top coating, should retard rapid drainage of the water or of the coating into the substrate. One way to accomplish this is by sizing the sheet, either internally or externally but generally externally. Preferably, external sizing is included in an intermediate impregnation coating which serves as a base for the top coating. The paper substrate can be texturized before or after coating to give different surface grains (e.g., such as molding or stamping a texture on the substrate).

Each of the coating composition layers can range in thickness from several hundred Angstroms to several mils in thickness, e.g., in the range of approximately 100 Angstroms to 5 mm; typical amounts of the coating composition to be applied generally



range from about 50 to about 500 pounds per ton of substrate, or about 2 to 30 g/m<sup>2</sup>. In one embodiment, the coating composition is applied so that the first layer does not substantially infiltrate into the substrate (e.g., the substrate is of a porosity such that the coating composition does not substantially penetrate beyond or far beyond the substrate surface). Application of a coating in a selected thickness can readily be done by one of skill in the art using known techniques, for example, by varying the coating agent concentration and number of coatings and through selection of the application means.

The coating compositions layers as described above are applied to any desirable paper substrate, usually to a type of pre-sized paper substrate commonly used in printing. Substrates for use in the invention include cellulose and non-cellulose type substrates (e.g., synthetic fibers such as polyamides, polyesters, polyethylene, and polyacrylic fibers; inorganic fibers such as asbestos, ceramic, and glass fibers), and/or any combination of cellulosic, synthetic, and inorganic fibers, with porous cellulose substrates being preferred. A preferred substrate for use herein is generally free cut sheet paper, with exemplary paper substrates including, but not limited to, copier grade paper, business card stock, resin-coated papers, cartons such as milk cartons and cardboard gift boxes. Additional exemplary substrates for use in the invention include polyester films such as "MYLAR" flexible film, polysulfones, polyvinyls, cellulose triacetates, and the like. Coated transparent films are also contemplated. Woven fabrics or simulated woven fabrics may also be used as the substrate. Molded sheets can be utilized. Further the paper substrate can have one or more adhesive layers which are optionally removable, before or after printing.

Processes for coating pre-sized paper substrates are well known in the art, and can be performed either on-machine, as alluded to above, or off-machine, i.e., subsequent to completion of paper manufacture. Generally, coating is accomplished by dip coating, reverse roll coating, extrusion coating, saturation, and the like.

#### Method for Providing Water-Resistant Images on Coated Paper

The invention also features a method for providing a water-resistant (e.g., water-fast) printed image on paper by applying a colorant to the ink-jet recording medium according to the invention, where the colorant contains reactive ionizable and/or nucleophilic groups capable of reacting with at least one coating agent in one or more of the layers of the ink-jet recording medium.

In general, aqueous inks are used in the preparation of a printed image on the ink-jet recording medium of the invention. The aqueous ink may be any suitable ink having a colorant, e.g., a pigment, dye, or stain, having one or more reactive groups suitable for reacting, either covalently or ionically, with a colorant-reactive component of the coating agent present on the coated paper substrate. The selection of the specific ink and colorant will vary with the colorant-reactive component of the coating agent used in coating the ink-jet medium. For example, when the colorant-reactive component is an azetidinium group, the colorant preferably has a nucleophilic group for reaction with the azetidinium group. Thus, preferred colorants for use in printing on a coated paper substrate having an azetidinium polymer in the polymer coating are those containing one or more nucleophilic moieties, e.g., having an amino, carboxy, sulfonato, thiosulfonato, cyano, hydroxy or sulfido group or the like. Preferred colorants for use in printing a paper substrate coated with a guanidine polymer are those containing an anionic group, e.g., having a carboxy, sulfonato, thiosulfonato, cyano, halo, or phosphonato group or the like.

The inks used in conjunction with the coated paper substrate of the invention may be inkjet inks. Water-soluble colorants in the inkjet inks may be acid dyes, direct dyes, basic dyes or dispersive dyes; preferred dyes for use in the invention are described in U.S. Pat. Nos. 5,425,805, 5,537,137, and 5,441,561.

The selection of the aqueous based ink will depend upon the requirements of the specific application, such as desired surface tension, viscosity, drying time, the type of paper substrate upon which the ink is to be applied (printing medium), and the like. The aqueous liquid vehicle of inks suitable for use in the invention will generally be deionized water, although other nonorganic compounds which are either water soluble or water miscible may be included as well. The colorant may be dissolved, dispersed or suspended in the aqueous liquid vehicle, and is present in an amount effective to provide the dried ink with the desired color and color intensity.

In some instances, the dye is contained in a carrier medium composed of ink and a water soluble organic solvent. For applications utilizing such a carrier medium, representative solvents include polyols such as polyethylene alcohol, diethylene glycol, propylene glycol, and the like. Additional solvents are simple alcohols such as ethanol, isopropanol and benzyl alcohol, and glycol ethers, e.g., ethylene glycol monomethyl ether, diethylene glycol monoethyl ether. Representative examples of water soluble organic solvents are described in U.S. Pat. No. 5,085,698 and U.S. Pat. No. 5,441,561.

Preferred colorants contained in the inks useful with the invention are dyes, including azo or "direct" dyes as well as dyes containing acidic groups (e.g., carboxylate, phosphonate or sulfonate moieties), basic groups (e.g., unsubstituted amines or amines substituted with 1 or 2 alkyl, typically lower alkyl, groups), or both. Specific examples of suitable colorants include, but are not limited to, the following: Dispersol Blue Grains (Zeneca, Inc.), Duasyn Acid Blue (Hoechst Celanese), Duasyn Direct Turquoise Blue (Hoechst Celanese), Phthalocyanine blue (C.I. 74160), Diane blue (C.I. 21180), Pro-jet Cyan 1 (Zeneca, Inc.), Pro-jet Fast Cyan 2 (Zeneca, Inc.), Milori blue (an inorganic pigment equivalent to ultramarine) as cyan colorants; Dispersol Red D-B Grains (Zeneca, Inc.), Brilliant carmine 6B (C.I. 15850), Pro-jet magenta 1 (Zeneca, Inc.), Pro-jet Fast magenta 2 (Zeneca, Inc.), Brilliant Red F3B-SF (Hoechst Celanese), Red 3B-SF (Hoechst Celanese), Acid Rhodamine (Hoechst Celanese), Quinacridone magenta (C.I. Pigment Red 122) and Thioindigo magenta (C.I. 73310) as magenta colorants; Dispersol Yellow D-7G 200 Grains (Zeneca, Inc.), Brilliant yellow (Hoechst Celanese), Pro-jet yellow 1 (Zeneca, Inc.), Pro-jet Fast Yellow 2 (Zeneca, Inc.), benzidine yellow (C.I. 21090 and C.I. 21100) and Hansa Yellow (C.I. 11680) as yellow colorants; organic dyes; and black materials such as carbon black, charcoal and other forms of finely divided carbon, iron oxide, zinc oxide, titanium dioxide, and the like. Specific and preferred black colorants include Acid Black 48 (Aldrich), Direct Black 58756 A (Crompton & Knowles), BPI Molecular Catalytic Gray (Brain Power), Fasday Cool Gray (Hunter Delator), Dispersol Navy XF Grains (Zeneca, Inc.), Dispersol Black CR-N Grains (Zeneca, Inc.), Dispersol Black XF Grains (Zeneca, Inc.), Disperse Black (BASF), Color Black FW18 (Degussa), Color Black FW200 (Degussa), Hostafine Black TS (Hoechst Celanese), Hostafine Black T (Hoechst Celanese), Duasyn Direct Black (Hoechst Celanese), Pro-jet Black 1 (Zeneca, Inc.) and Pro-jet Fast Black 2 (Zeneca, Inc.).

#### Printed Ink-jet Recording Medium

The invention also features a printed, ink-jet recording medium which is a coated paper substrate produced as described herein. The printed, ink-jet recording medium of the invention can be produced by any of a variety of printing techniques, including inkjet printing, laserjet printing, photocopying, and the like. In general, the printing process involves applying an aqueous recording liquid to a coated paper substrate in an imagewise pattern. Inkjet printing processes are well known in the art; see, e.g., U.S. Pat. Nos. 4,601,777; 4,251,824; 4,410,899; 4,412,224; and 4,532,530.

The ink-jet recording medium of the invention can also be used in printing and/or copying process using dry or liquid electrophotographic-type developers, such as electrophotographic processes, ionographic process, and the like. The coated paper substrates of the invention can in addition be used in a process for generating images that involves generating an electrostatic latent image on an imaging member in an imaging apparatus, developing the latent image with a toner, and transferring the developed image to a coated paper substrate of the invention. Electrophotographic processes are known in the art, see, e.g., U.S. Pat. No. 2,297,691. Ionographic and electrographic processes are also well known in the art, see, e.g., U.S. Pat. Nos. 3,611,419; 3,564,556; 4,240,084; 4,569,584; 2,919,171; 4,524,371; 4,619,515; 4,463,363; 4,254,424; 4,538,163; 4,409,604; 4,408,214; 4,365,549; 4,267,556; 4,160,257; and 4,155,093.

The ink-jet recording medium of the invention can also be used in any other printing or imaging process, such as printing with pen plotters, handwriting with ink pens (either aqueous or nonaqueous based inks), offset printing processes, and the like.

## 15 Experimental

The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how to prepare and use the compounds disclosed and claimed herein. Efforts have been made to ensure accuracy with respect to numbers (e.g., amounts, temperature, etc.) but some errors and deviations should be accounted for. Unless indicated otherwise, parts are parts by weight, temperature is in .degree. C. and pressure is at or near atmospheric.

### Examples of Layer 1 Compositions

#### Layer 1 – Example 1

	Hydroxyethyl methacrylate-methacrylic acid copolymer (~25 wt%)	60 parts
25	Polyamide-epichlorohydrin resin (~12.5 wt%)	30 parts
	Polyethylene glycol (100 wt%)	10 parts

#### Layer 1 – Example 2

	Polyvinyl alcohol(10 wt%)	50 parts
	Polyamide-epichlorohydrine resin (~12.5 wt%)	40 parts
30	Polyethylene glycol (100 wt %)	10 parts

Layer 1 – Example 3

Cationic polyurethane (~30 wt%)	70 parts
Polyamide-epichlorohydrine resin (~12.5 wt%)	20 parts
Polyethylene glycol	10 parts

5 Layer 1 – Example 4

Hydroxyethyl methacrylate-methacrylic acid copolymer (~25%)	60 parts
Polyfunctional aziridine (100 wt %)	30 parts
Polyethylene glycol	10 parts

Layer 1 – Example 5

10 Polyvinyl alcohol (10 wt %)	50 parts
Polyfunctional aziridine	40 parts
Polyethylene glycol 200 plasticizer(100 wt %)	10 parts

Layer 1 – Example 6

Cationic polyurethane (~30 wt %)	70 parts
15 Polyfunctional aziridine	20 parts
Polyethylene glycol 200 plasticizer (100 wt %)	10 parts

**Examples of Layer-2 Compositions**Layer 2 – Example 1

Hydroxyethyl methacrylate-methacrylic copolymer (~25 wt%)	15 parts
20 Quarternized acrylic copolymer (~20 wt%)	20 parts
Chlorohexidine salt (20wt%)	10 parts
Isopropanol	20 parts
Water	34 parts
Surfactants and plasticizers	1 part

25 Layer 2 – Example 2

Hydroxyethyl methacrylate-methacrylic acid copolymer (~25 wt%)	10 parts
Quarternized acrylic copolymer (~20 wt%)	25 parts
Chlorohexidine salt (20 wt%)	5 parts
Polyvinylamine polymer (25 wt%)	10 parts
30 Isopropanol	25 parts
Water	24 parts
Surfactants and plasticizers	1 part

Layer 2 – Example 3

	Hydroxyethyl methacrylate-methacrylic acid copolymer (~25 wt%)	18 parts
	Quarternized acrylic copolymer (~20 wt%)	20 parts
	Chlorohexidine salt (20 wt%)	6 parts
5	Polyvinylamidine polymer (20 wt%)	16 parts
	Isopropanol	22 parts
	Water	26 parts
	Surfactants and plasticizers	1 part

Layer 2 – Example 4

10	Hydroxyethyl methacrylate-methacrylic acid copolymer (~25 wt%)	25 parts
	Quarternized acrylic copolymer (~20 wt%)	15 parts
	Polyvinyl alcohol (~10 wt%)	5 parts
	Chlorohexidine salt (20 wt%)	13 parts
	Poly biguanidine polymer (20 wt%)	2 parts
15	Isopropanol	22 parts
	Water	26 parts
	Surfactants and plasticizers	1 part

Layer 2 – Example 5

	Quaternized hydroxyethyl methacrylate copolymer (~20 wt%)	30 parts
20	Polyvinyl alcohol (10 wt%)	15 parts
	Chlorohexidine salt (20 wt%)	10 parts
	Polyvinylamidine polymer (25 wt%)	4 parts
	Isopropanol	25 parts
	Water	15 parts
25	Surfactants and plasticizers	1 part

**Typical Product Examples and Procedures**30 Coated Product Example 1

## Layer-1

	Hydroxyethyl methacrylate-methacrylic acid copolymer (~25 wt%)	60 parts
	Polyaminoamide epichlorohydrine resin (~12.5 wt%)	30 parts
35	Polyethylene glycol (100wt%)	10 parts

*The layer-1 made of the above composition is coated on the substrate (canvas, glossy substrate, metallized substrate) using a Myer Rod #30 and the coating is dried in the oven ~80 degrees for a few minutes*



## Layer-2

	Hydroxyethyl methacrylate-methacrylic acid copolymer (~25 wt%)	20 parts
	Quarternized acrylic copolymer (~20 wt%)	15 parts
	Chlorohexidine salt (20wt%)	10 parts
5	Isopropanol	20 parts
	Water	34 parts
	Surfactants and plasticizers	1 part

10 *The layer-2 is coated on the substrate that was earlier coated with the first layer, using Myer rod # 80 and dried in the oven ~80 degrees for about three minutes.*

*Results - The coated and dried substrates produce high gloss (~90) and when printed with ink jet printers produced bright colors and water fast prints.*

Coated Product Example 2

## 15 Layer-1

	Cationic polyurethane (~30 wt%)	70 parts
	Polyamide-epichlorohydrine resin (~12.5 wt%)	20 parts
	Polyethylene glycol 200 plasticizer	10 parts

20 *The layer-1 made of the above composition is coated on the substrate (canvas, glossy substrate, metallized substrate) using a Myer Rod #30 and the coating is dried in the oven ~80 degrees for a few minutes*

## Layer-2

25	Hydroxyethyl methacrylate-methacrylic acid copolymer (~25 wt%)	20 parts
	Quarternized acrylic copolymer (~20 wt%)	15 parts
	Chlorohexidine salt (20wt%)	10 parts
	Isopropanol	20 parts
	Water	34 parts
30	Surfactants and plasticizers	1 part

*The layer-2 is coated on the substrate that was earlier coated with the bottom layer, using Myer rod # 80 and dried in the oven ~80 degrees for three minutes.*

35 *Results - The coated and dried substrates produce high gloss (~90) and when printed with ink jet printers produce optically bright and water fast prints.*

Coated Product Example 3

## Layer-1

40	Polyvinyl alcohol(10 wt%)	50 parts
	Polyfunctional aziridine(~12.5 wt%)	40 parts
	Polyethylene glycol 200 plasticizer (100 wt %)	10 parts

*The layer-1 made of the above composition is coated on the substrate (canvas, glossy substrate, metallized substrate) using a Myer Rod #30 and the coating is dried in the oven ~80 degrees for a few minutes*

5

#### Layer-2

	Hydroxyethyl methacrylate-methacrylic acid copolymer (~25 wt%)	20 parts
	Quarternized acrylic copolymer (~20 wt%)	15 parts
	Chlorohexidine salt (20wt%)	10 parts
10	Isopropanol	20 parts
	Water	34 parts
	Surfactants and plasticizers	1 part

15 *The layer-2 is laid on the substrate that was earlier coated with the bottom layer, using Myer rod # 80 and dried in the oven ~80 degrees for three minutes.*

*Results - The coated and dried substrates produced high gloss (~90) and when printed with ink jet printers to yield optically bright and water fast prints.*

20 Without further description, it is believed that one of ordinary skill in the art can, using the preceding description, make and utilize the compositions of the present invention and practice the claimed methods. The examples of coating compositions and methods as well as their proportions, specifically point out preferred embodiments of the present invention, and are not to be construed as limiting in any way the remainder of the

25 disclosure. Such examples are non-limiting in that one of ordinary skill (in view of the above) will readily envision other permutations and variations on the invention without departing from the principal concepts. Such permutations and variations are also within the scope of the present invention.

*Claims*

- 1     1.     An ink-jet recording medium, suitable for recording images with dye and  
2     pigmented inks, comprising a substrate coated with at least two layers comprising:  
3         (a)     a first ink-receptive layer comprising a polymeric binder and a cross-linker  
4                 and optionally having a plasticizer coated over the substrate; and  
5         (b)     a second layer comprising of 45 to 98% of polymeric binders where at  
6                 least one binder is selected from group consisting of:  
7                 (i) a copolymer of hydroxyethylmethacrylate, a polymer and copolymer of  
8                 vinylpyrrolidone, and  
9                 (ii) a fully or partially hydrolyzed polyvinyl alcohol and its derivatives, and  
10                combination thereof,  
11                (iii) Polyethyloxazoline  
12                wherein the second layer optionally further contains at least one  
13                nitrogeneous polymer or its salt, at least one non-polymeric nitrogenous  
14                compound or its salt, or a mixture thereof,  
15                wherein said first layer is located between said second layer and the substrate in  
16                said recording medium.
- 1     2.     An ink-jet recording medium according to claim 1, wherein the second layer  
2     comprises a nitrogenous polymer or compound having a pKa higher than 8 and wherein  
3     the nitrogenous polymer or compound is a member selected from the group consisting of:  
4         (i)     polyhexylmethylbiguanidine or a salt thereof,  
5         (ii)     polyvinylamidine or a salt thereof,  
6         (iii)    chlorhexidine or a salt thereof, and  
7         (iv)    a mixture of 2 or more of (i)-(iii).
- 1     3.     An ink-jet recording medium according to claim 2 wherein the salt of the basic  
2     nitrogenous moiety of the dye-fixing compound or polymer is formed of a cation with a  
3     counter ion selected from the group consisting of an organic or inorganic anion.
- 1     4.     An ink-jet recording medium according to claim 3 wherein the anion of the salt is a  
2     member selected from the group consisting of halide, hydrogen sulfate, acetate, methane  
3     sulfonate, succinate, citrate, malonate, furarate, oxylate, gluconate or a gluconate  
4     derivative.

1 5. The ink-jet recording medium according to claim 4, wherein the anion of the salt is  
2 gluconate or a gluconate derivative.

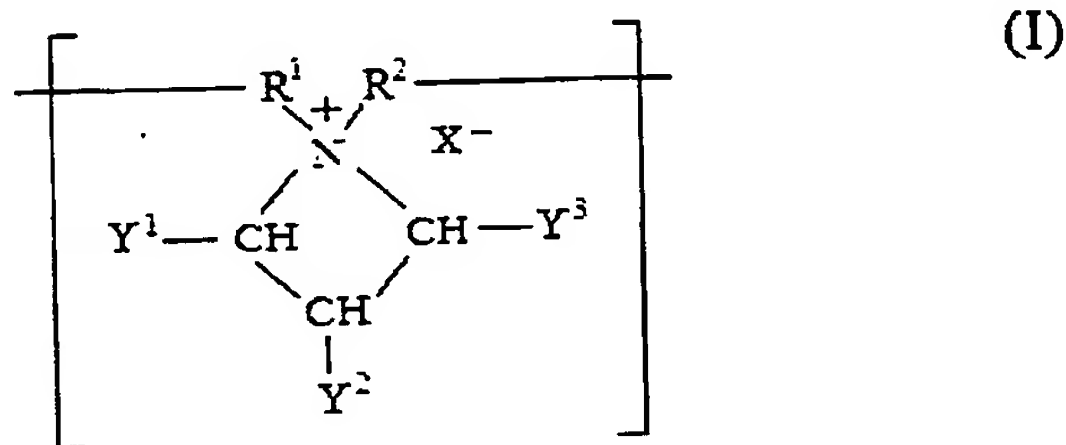
1 6. The ink-jet recording medium according to claim 1, wherein the cross-linker of (a)  
2 comprises an azetidinium polymer or salt thereof and a polyfunctional aziridine or a salt  
3 thereof.

1 7. The ink-jet recording medium according to claim 6, wherein the azetidinium  
2 polymer or salt thereof is a homopolymer or salt thereof.

1 8. The ink-jet recording medium according to claim 6, wherein the azetidinium  
2 polymer or salt thereof is a copolymer or salt thereof.

1 9. The ink-jet recording medium according to claim 6, wherein the azetidinium  
2 polymer or salt thereof comprises polyaminoamide-epichlorohydrin resin, or a salt thereof.

1 10. The ink-jet recording medium according to claim 6, wherein the azetidinium  
2 polymer salt is comprised of monomer units having the structural formula:



3  
4 in which  $\text{R}^1$  and  $\text{R}^2$  are independently lower alkylene,  $\text{X}^-$  is an anionic, organic or  
5 inorganic counterion, and  $\text{Y}^1$ ,  $\text{Y}^2$  and  $\text{Y}^3$  are selected from the group consisting of  
6 hydrogen, hydroxyl, halo, alkoxy, alkyl, amino, carboxy, acetoxy, cyano and sulfhydryl.

1 11. The ink-jet recording medium according to claim 10, wherein the  $\text{X}^-$  anion of the  
2 salt is a member selected from the group consisting of halide, hydrogen sulfate, acetate,  
3 methane sulfonate, succinate, citrate, malonate, fumarate, oxylate, gluconate or a  
4 gluconate derivative.

1 12. The ink-jet recording medium according to claim 11, wherein, in the azetidinium  
2 polymer,  $R^1$  and  $R^2$  are methylene,  $Y^1$  and  $Y^3$  are independently hydrogen or lower alkyl,  
3 and  $Y^2$  is hydrogen or hydroxyl.

1 13. The ink-jet recording medium according to claim 12, wherein wherein  $Y^1$  and  $Y^3$   
2 are both hydrogen,  $Y^2$  is hydroxyl and  $X^-$  is a chloride anion.

1 14. The ink-jet recording medium of claim 2, wherein the first and second layers  
2 comprise polymers that are soluble in an aqueous solvent or are soluble in a solvent  
3 mixture of an aqueous solvent and a polar organic solvent.

1 15. The ink-jet recording medium of claim 14, wherein the polar organic solvent is an  
2 alcohol.

1 16. The ink-jet recording medium of claim 7, wherein the second layer contains at  
2 least one polymer that is soluble in an aqueous solvent or in a solvent mixture of an  
3 aqueous solvent and a polar organic solvent and the polymer is a member selected from a  
4 group hydroxyethylmethacrylate copolymer or terpolymer, or a derivative thereof, wherein  
5 the copolymer or terpolymer comprises at least one member of the group consisting of 2-  
6 hydroxyethylmethacrylate/co-acrylic acid copolymer,  
7 2-hydroxyethylmethacrylate/methacrylic acid copolymer, 2-hydroxyethyl-  
8 methacrylate/dimethylaminopropylmethacrylate, 2-hydroxyethylmethacrylate/dimethyl-  
9 aminoethylmethacrylate, and 2-hydroxyethylmethacrylate-vinylpyrrolidone, quaternized  
10 polyhydroxyethylmethacrylate-co-dimethylaminopropylmethacrylate, quaternized  
11 polyhydroxyethylmethacrylate-co-dimethylaminoethylmethacrylate;  
12 vinylpyrrolidone polymers and copolymers are selected from the group consisting  
13 polyvinylpyrrolidone vinylpyrrolidone/dimethylaminoethyl methacrylate copolymer, vinyl  
14 caprolactam/vinylpyrrolidone/dimethylaminoethyl methacrylate terpolymer,  
15 vinylcaprolactam/vinylpyrrolidone/dimethylaminopropyl methacrylamide terpolymer,  
16 vinylpyrrolidone/dimethylaminopropyl methacrylamide copolymer,  
17 vinylpyrrolidone/dimethylaminoethyl methacrylate copolymer, and quaternized  
18 derivatives thereof.

1 17. The ink-jet recording medium of claim 14, wherein the concentration of the  
2 polyhexamethylenebiguanidine and its salts in combination in the second layer (b) is from  
3 about 1% to about 5% by weight of the dry coat weight of the second layer.

1 18. The ink-jet recording medium of claim 16, wherein the first layer comprises at  
2 least one member selected from the group consisting of partially or fully hydrolysed  
3 polyvinyl alcohol and their derivatives, a HEMA copolymers, vinylpyrrolidone polymers  
4 and co-polymers and cationic polyurethane and a mixture of at least two members thereof.

1 19. The ink-jet recording medium of claim 18, wherein the first layer composition  
2 further contains at least one cross-linker selected from group consisting of a polyamide-  
3 epichlorohydrin resin or a salt thereof, a polyfunctional aziridine or a salt thereof, and a  
4 mixture thereof.

1 20. The ink-jet recording medium of claim 18, wherein the first layer composition  
2 contains an azetidinium compound, or salt thereof, as a polyamide-epichlorhyrin cross-  
3 linker.

1 21. The ink-jet recording medium of claim 2, wherein each of the first and second  
2 layers may independently include a plasticizer which is a member selected from the group  
3 consisting of phosphates, substituted phthalic anhydrides, glycerols, and polyglycols.

1 22. The ink-jet recording medium of claim 21, wherein the plasticizer is polyethylene  
2 glycol or a derivatives thereof.

1 23. The ink-jet recording medium of claim 2, wherein the second layer further  
2 comprises a white pigment.

1 24. The ink recording medium of claim 2, wherein the second layer further comprises  
2 organic particulates selected from the group consisting of starch, polyolefins, poly(methyl  
3 methacrylates), polystyrenes, polytetrafluoroethylenes, and polyurethanes.

1 25. The ink-jet recording medium of claim 1, wherein the second layer further  
2 comprises additives selected from the group consisting of antifoam agents, surfactants,  
3 dyestuffs, optical brighteners, and mixtures thereof.

1 26. The ink-jet recording medium of claim 2, wherein the substrate is a paper or  
2 polymeric film.



- 1 27. The ink-jet recording medium of claim 26, wherein the substrate is a paper selected  
2 from the group consisting of plain, clay-coated, resin-coated, and latex-saturated papers.
- 1 28. The ink-jet recording medium of claim 26, wherein the substrate is a polymeric  
2 film selected from the group consisting of polyvinyl chloride, polyethylene,  
3 polypropylene, polycarbonate, polyimide, polyester, and fluoroplastic films.
- 1 29. The ink-jet recording medium of claim 28, wherein the coated substrate is glossy  
2 and opaque, transparent, translucent, matte, or opaque.
- 1 30. The ink-jet recording medium of claim 28, wherein one or more functional or non-  
2 functional coating layers are placed between the paper substrate and two coating layers (a)  
3 and (b).
- 1 31. A method for providing a water-resistant image on the ink-jet recording medium of  
2 claim 2, comprising applying an ink composition to the recording medium, wherein the  
3 ink composition comprises a dye having ionizable and/or nucleophilic groups capable of  
4 reacting with a dye-fixing compound.
- 1 32. The method of claim 31, wherein the dye composition is a predominantly aqueous  
2 based ink or is an ink having a mixed solvent of at least one aqueous solvent and at least  
3 one aqueous miscible organic solvent.
- 1 33. A printed paper product prepared by a method comprising applying an ink  
2 composition to the ink-jet recording medium of claim 2, wherein the ink composition  
3 comprises a dye having ionizable and/or nucleophilic groups capable of reacting with a  
4 dye-fixing compound.
- 1 34. A printed paper product prepared by a method comprising applying an ink  
2 composition to the ink-jet recording medium of claim 2, wherein the ink composition  
3 comprises a dye having ionizable and/or nucleophilic groups capable of reacting with a  
4 dye-fixing compound, and wherein the dye composition is a predominantly aqueous based  
5 ink or is an ink having a mixed solvent of at least one aqueous solvent and at least one  
6 aqueous miscible organic solvent.

1 35. A printed paper product having one surface of the product comprising an adhesive  
2 backing that is optionally removable, wherein the paper product is prepared by a method  
3 comprising applying an ink composition to the ink-jet recording medium of claim 2 and  
4 the ink composition comprises a dye having ionizable and/or nucleophilic groups capable  
5 of reacting with a dye-fixing compound.

1 36. A printed paper product having one surface of the product comprising an adhesive  
2 backing that is optionally removable, wherein the paper product is prepared by a method  
3 comprising applying an ink composition to the ink-jet recording medium of claim 2 and  
4 the ink composition comprises a dye having ionizable and/or nucleophilic groups capable  
5 of reacting with a dye-fixing compound, wherein the dye composition is a predominantly  
6 aqueous based ink or is an ink having a mixed solvent of at least one aqueous solvent and  
7 at least one aqueous miscible organic solvent.

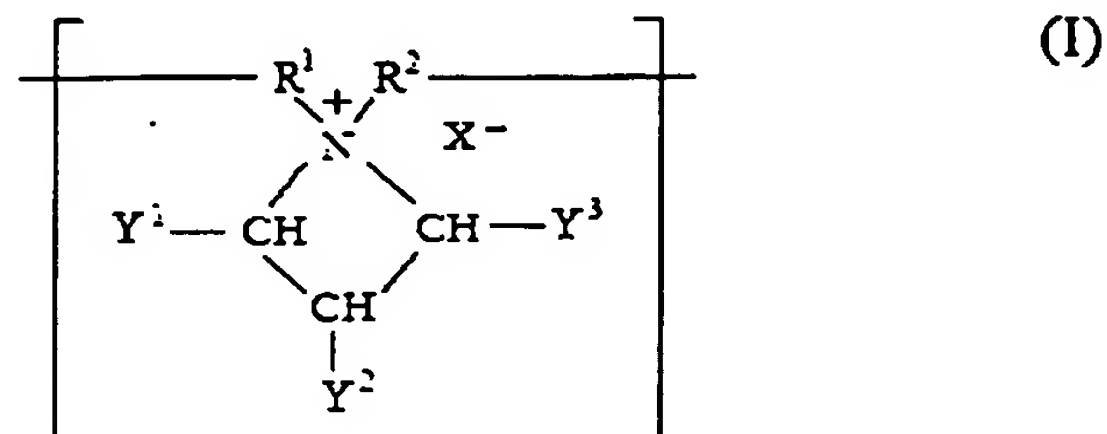
1 37. An intermediate substrate suitable for further coating with additional layers to  
2 produce an ink-jet recording medium for recording images with dye and pigmented inks,  
3 comprising an intermediate substrate coated with at least one ink-receptive layer  
4 comprising a polymeric binder and a cross-linker and optionally having a plasticizer  
5 coated over the substrate, wherein the cross-linker comprises an azetidinium polymer or a  
6 salt thereof and a polyfunctional aziridine or a salt thereof.

1 38. The intermediate substrate according to claim 37, wherein the azetidinium polymer  
2 or salt thereof is a homopolymer or salt thereof.

1 39. The intermediate substrate according to claim 37, wherein the azetidinium polymer  
2 or salt thereof is a copolymer or salt thereof.

1 40. The intermediate substrate according to claim 37, wherein the azetidinium polymer  
2 or salt thereof is a composition further comprising polyamideepichlorohydrin resin, or a  
3 salt thereof.

- 1 41. The intermediate substrate according to claim 37, wherein the azetidinium polymer  
2 salt is comprised of monomer units having the structural formula:



- 3  
4 in which  $\text{R}^1$  and  $\text{R}^2$  are independently lower alkylene,  $\text{X}^-$  is an anionic, organic or  
5 inorganic counterion, and  $\text{Y}^1$ ,  $\text{Y}^2$  and  $\text{Y}^3$  are selected from the group consisting of  
6 hydrogen, hydroxyl, halo, alkoxy, alkyl, amino, carboxy, acetoxy, cyano and sulfhydryl.

- 1 42. The intermediate substrate according to claim 41, wherein the  $\text{X}^-$  anion of the salt  
2 is a member selected from the group consisting of halide, hydrogen sulfate, acetate,  
3 methane sulfonate, succinate, citrate, malonate, furarate, oxylate, gluconate or a gluconate  
4 derivative.

- 1 43. The intermediate substrate according to claim 42, wherein, in the azetidinium  
2 polymer,  $\text{R}^1$  and  $\text{R}^2$  are methylene,  $\text{Y}^1$  and  $\text{Y}^3$  are independently hydrogen or lower alkyl,  
3 and  $\text{Y}^2$  is hydrogen or hydroxyl.

- 1 44. The intermediate substrate according to claim 43, wherein  $\text{Y}^1$  and  $\text{Y}^3$  are both  
2 hydrogen,  $\text{Y}^2$  is hydroxyl, and  $\text{X}^-$  is a chloride anion.

- 1 45. The intermediate substrate according to claim 41, wherein the ink-receptive  
2 substrate layer comprises polymers that are soluble in an aqueous solvent or are soluble in  
3 an aqueous solvent and a polar organic solvent.

46. The intermediate substrate according to claim 45, wherein the polar organic  
solvent is an alcohol.

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/20420

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B41M 5/00

US CL : 428/195

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/195, 212, 341, 342

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,387,473 A (SISMONDI et al.) 14 May 2002, see Abstract.	1-46
A, B	US 6,592,953 A (CERUTI et al.) 15 July 2002, see Abstract.	1-46

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

25 August 2003 (25.08.2003)

Date of mailing of the international search report

10 SEP 2003

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